Effects of restoration on the primary seed disperser of whitebark pine on the Sawtooth National Forest

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Understanding the response of whitebark pine (WBP) ecosystems to restoration treatments is of utmost importance, especially given WBP's recent listing under the Endangered Species Act (ESA) (USFWS 2022). A Recovery Team is currently supporting the development of a recovery plan for WBP, as required by the ESA. However, a central challenge for recovery planning is the lack of information about the efficacy and effects of silvicultural restoration treatments, such as thinning and daylighting (Tomback *et al.* 2022). There are only a handful of projects for which monitoring results have been shared and, to our knowledge, monitoring has focused on vegetation (Keane and Parsons 2010, Maher *et al.* 2018, Martelli *et al.* 2023) and has not assessed effects on the tree's primary seed disperser, Clark's nutcrackers (CLNU). CLNU are cited ubiquitously in WBP restoration literature as being integral to the persistence of the species across its range as well as its resilience to climate change (Tomback 1982, McKinney *et al.* 2009, Tomback *et al.* 2011, Keane *et al.* 2012, Kovaleknko *et al.* 2024). Yet, despite CLNUs' crucial importance to regeneration, genetic diversity, and persistence of WBP, little is known about how restoration treatments and the ensuing stand conditions affect CLNU visitation and seed dispersal. This lack of information is a substantial hurdle in effectively managing WBP across the species' range.

To improve understanding of restoration treatments and wildlife impacts on WBP, in 2023 the Sawtooth National Forest (SNF) received funding from USFWS to develop and implement a monitoring program to assess the effects of fire and silvicultural thinning treatments. In 2023, University of Montana's Restoration Ecology Lab, directed by Dr. Cara Nelson, analyzed the reliability of previously collected monitoring data from the SNF, and used that analysis to develop and test a revised vegetation monitoring protocol. In summer 2024, I will use the protocol to conduct pre-treatment sampling. However, the protocol is limited to vegetation variables, and does not include sampling of CLNUs, despite the critical need to understand their responses to treatment. Thus, I will also implement passive acoustic monitoring (Doser *et al.* 2021, Cole *et al.* 2022) in tandem with forest monitoring to evaluate the effects of WBP restoration treatments on CLNU habitat selection and use.

This project would complement the *Whitebark Monitoring on the Sawtooth National Forest* project by expanding monitoring to include restoration treatment effects on WBP's primary seed disperser. Although the monitoring will be done in the SNF, the intention is to develop and test the monitoring design so that it can be utilized range wide. Specific monitoring questions include: (1) What are the effects of silvicultural treatments and prescribed fire on CLNU habitat selection and use in WBP stands? and (2) What are the effects of stand characteristics, including cone density, mean tree diameter, basal area, tree mortality, and tree health on CLNU habitat selection and use in WBP stands?

During summer 2024, the companion project, *Whitebark Monitoring on the Sawtooth National Forest*, will collect pre-treatment data from three project areas using a before-after control-impact design (BACI). Within each treatment and control area, an approximately 5-ha unit (site) will be designated for sampling. Plots will be systematically placed on a grid with 40-m spacing.

Extensive vegetation sampling will take place at 10 fixed-radius (11.28-m; 0.04 ha) plots per site as detailed in the companion proposal. Vegetation plots will generally be installed at every other grid point. For this project, Acoustic recording units (ARUs) will be installed within two treatment and two control areas, with five ARUs co-located with vegetation sampling at each site (20 recorders total; five ARUs x four sites). We will maintain a distance of >100 m between ARUs so vocalizations are not double counted. Bird ecologist Vlad Kovalenko will locate and program the ARUs (Swift, Cornell Lab of Ornithology) to record all environmental sounds in the morning and evening, mid-August to mid-September, typically the height of CLNU foraging in WBP.

After concluding the field season, Institute for Bird Populations biologist Dr. Mary Clapp will store and analyze the recordings to quantify vocal activity of CLNU and any other species of vocalizing animal. The first year of data collection (2024) will provide pre-treatment baseline data, to which I will be able to compare post-treatment data from subsequent years. To ensure successful post-treatment sampling, I will also analyze the precision of estimation within each unit using the five ARUs, to determine the required number of ARUs to use to get reliable estimates of mean bird vocalizations in each experimental unit. Once post-treatment data are collected, generalized linear or N-mixture models will be fit with a BACI structure that mirrors the analytical structure of the vegetation proposal, to assess the relationship between treatments and CLNU vocal activity (Priol *et al.* 2014) as a proxy for CLNU habitat use. The generalized linear mixed models will also include habitat characteristics of importance to CLNU, such as cone density and basal area of live WBP.

This study will give resource managers a more complete understanding of the ecosystem they are trying to conserve and restore by pairing bird and vegetation data collection. It will generate large quantities of acoustic data which may lead to further insights into-a large suite of WBP-associated wildlife. Second, it will-contribute to understanding the effects of WBP management and restoration on the tree's primary natural seed disperser, the CLNU, by collecting pre-treatment data; additional funds are being sought for post-treatment data collection. A third outcome will be improved protocols for monitoring the effects of WBP-restoration and management treatments on CLNU, which are vital for WBP recovery. Although the project will result in a set of protocols developed for the SNF, these protocols will be applicable across the range of WBP. The protocols that are developed will be documented in detail to ensure that they can be followed with low observer error. Data will be entered into a database with appropriate metadata documentation and shared with the USFS for archiving.

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